SUB-SURFACE PEAT TEMPERATURES AT MT. KOSCIUSKO, N.S.W.

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(One Text-figure.)

[Read 27th November, 1946.]

Introduction.

The Kosciusko Plateau is a remnant of an early Tertiary peneplain, elevated by late Tertiary uplifts to a height of 6,000 to 7,300 feet above sea-level, and extensively dissected by subsequent erosion (Andrews, 1910). The plateau, representing the highest country in Australia, was glaciated during Pleistocene time (David, 1908; Browne, Dulhunty and Maze, 1944); and an alpine environment now exists, although glacial conditions have disappeared.

The highest portions of the plateau are covered with snow from eight to nine months of the year, and snow patches occasionally survive from one winter to another. During summer there is an abundant growth of vegetation (McLuckie and Petrie, 1927), and some small forms of animal life are active. Soils consist mainly of sand and gravel derived from granite which is the principal rock-type, although restricted outcrops of phyllite, occurring along the crest of the Main Divide, give rise to sandy clay. On slopes and hill sides the surface layer of soil, 6 to 18 inches deep, is of dark colour due to accumulation of humus. Peat formation occurs in upland swamps situated on undissected portions of the plateau where drainage is obstructed by moraines and topographical features produced by glaciation. Each winter the swamp vegetation is buried beneath snow, and compressed into a fibrous mat to which new growth is added each summer. Owing to the high level of swamp water and low temperatures, the rate of accumulation of plant débris exceeds that of decay, and, in some places, immature peat beds have been built up to a depth of 15 feet.

A preliminary investigation of peat temperatures was undertaken, as nothing was known of the sub-surface temperature conditions during summer and winter on the Kosciusko Plateau; and it appeared that results might be of value in the study of peat formation, biological problems, development of soils, and weathering of rock by frost action.

Temperature Determinations.

The investigation was carried out in a slightly elevated peat bed at the southern side of a swampy area on a headwater tributary of the Snowy River between Etheridge Range and Mt. Clark, in a valley to the north of, and beneath, Seaman's Hut. The peat bed is situated N. 56° E. from Mt. Kosciusko and S. 11° W. from Mt. Clark, at an elevation of 6,200 feet above sea-level. The position was chosen as it represents average conditions on the plateau, and results should be more or less typical for swamp lands of similar elevation.

On the 22nd January, 1945, a hole 6 feet 6 inches deep was excavated in the peat bed which was 6 feet thick, with gravel at its base. Three horizontal bore holes, 3 inches in diameter and 5 feet long, were made in one wall of the excavation at depths of 9 inches, 3 feet, and 6 feet from the surface, as illustrated in Figure 1. As soon as the holes were completed, maximum- and minimum-recording thermometers were placed at the ends of the holes which were then plugged with peat removed during boring. After seven days the thermometers were taken out, and the maximum temperatures, recorded at the three levels in the peat, were noted. The thermometers were then replaced in the bore holes which were plugged as before, and the excavation was filled in and allowed to remain through the winter when the peat bed was covered with snow. On the 21st January, 1946, the excavation was opened up, the thermometers withdrawn from the bore holes, and the minimum temperatures, recorded at the different levels, were observed.

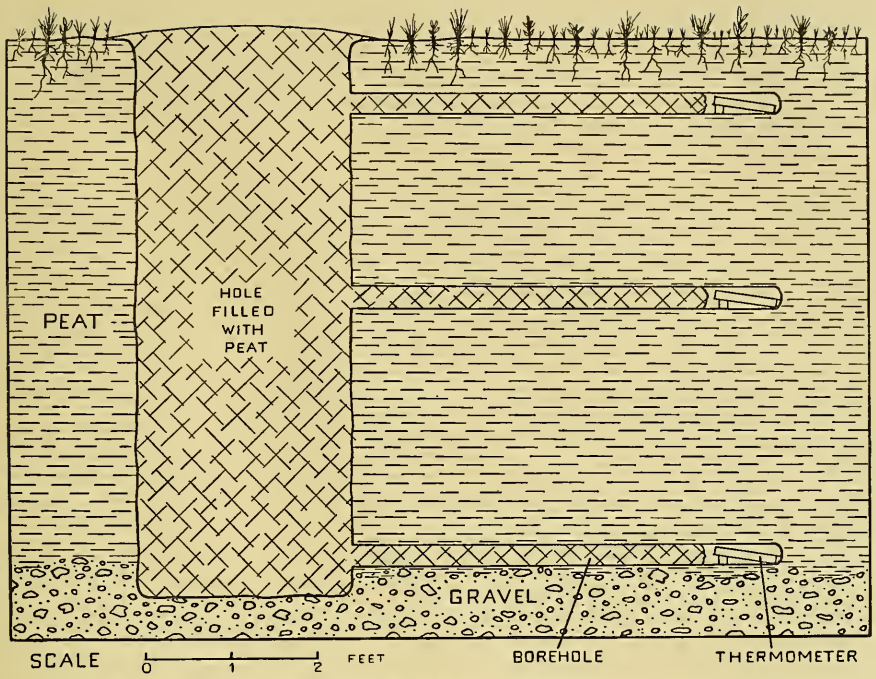

Fig. 1.—Method of determining sub-surface temperatures in peat bed.

The thermometers were standardized before and after the investigation by packing in ice for 24 hours to find amounts of error at 32°F., and readings were then taken in water at 41° and 52°F. The differences between readings, amounting to less than 1°F., were the same at the three different temperatures, indicating that the error for each thermometer was constant over the temperature-range employed. Actual readings recorded in the peat were converted to true temperatures by correcting for the error in each thermometer. The summer and winter temperatures, correct to ¼°F., are shown in Table 1.

TABLE 1.
Summer and Winter Temperatures in Peat Bed at Mt. Kosciusko.

Position in Peat Bed.	Sub-Surface Temperatures.	
	Maximum recorded between 22nd–29th Jan., 1945.	Minimum recorded between 29th Jan., 1945–21st Jan., 1946.
At surface	63·00° F.	32·00° F.
9 inches down	50·50° F.	34·00° F.
3 feet down	44·25° F.	36·50° F.
6 feet down	43·75° F.	38·50° F.

The summer surface temperature of 63°F. was the average maximum daily temperature recorded on the surface of the ground, shaded by grass and herbage, during three weeks in January, 1945. The winter surface temperature was taken at 32°F., as the ground is covered with snow in which a temperature of 32°F. is maintained by equilibrium between heats of melting and freezing of ice and water. This was verified, to a certain extent, by the fact that the temperature at the base of a large snow patch, some 20 feet deep, was found to be exactly 32°F.

Extrapolation of the results, in the case of peat beds thicker than the one investigated, suggests that a temperature of 41° to 42°F., with very little seasonal variation,

exists at depths below 6 feet. It would appear, however, that extrapolation should not be carried below the base of any peat bed, as temperatures in underlying material may vary from place to place, depending on thickness of gravel separating peat from solid rock and the circulation of ground water. Very little movement of water takes place in the peat, but free circulation in underlying gravel may cause considerable seasonal variation in temperature below its base.

Conclusions.

In drawing conclusions from the preliminary results recorded in this paper, it is necessary to take into consideration the fact that they represent conditions which existed in one particular peat bed at the end of January, 1945, and during the ensuing winter. The figures for summer conditions represent the temperature gradient in the peat at the time when readings were taken. It is probable that the temperature at deeper levels (3 to 6 feet) would increase towards the end of summer, owing to the well-known lag in seasonal adjustment of soil temperatures (Moore, 1910). The winter temperatures, representing the minimum temperatures reached at different levels, can not be regarded as a gradient because they probably obtained at different times during the winter. While covered with snow, the ground would lose heat accumulated in summer, and the minimum temperature of 38·5°F. at 6 feet was probably reached at the end of winter—or even after the snow had disappeared, but before warmth from summer conditions penetrated to the deeper levels.

The extent to which the results may be taken as representative of the plateau area above about 5,500 feet is debatable until further results have been obtained at various elevations in different places. It appears probable, however, that sub-surface temperatures at depths greater than 9 inches in swampy areas and on hill sides of gentle slope rarely fall below 32°F., although very low temperatures (possibly approaching zero) are experienced at the surface as a result of frosts and blizzards towards the end of summer, before winter snow commences to lie on the ground. When covered with snow, the ground is shielded from the extremely low temperatures (below zero) which frequently occur in winter, and its surface appears to be maintained at the equilibrium temperature of 32°F.

Data regarding sub-surface temperatures have important applications in the study of peat formation. It is evident that the formation of peat on the Kosciusko Plateau is largely due to repression of organic decay by anaerobic conditions and low temperatures prevailing throughout the year at depths below 2 feet in the peat beds. On slopes and hill sides, decay is arrested while winter snow covers the ground; but in summer the water level falls below the surface, and warmer aerobic conditions allow decay to proceed more rapidly than in swampy areas, producing a high-humus soil rather than a peat.

Disintegration of rocks by frost action (expansion of water as it freezes in cracks and interstitial spaces) would appear to be limited to exposed rock surfaces, as the foregoing results suggest that sub-surface temperatures in saturated soil do not fall to 32°F. During winter, when frost action would be most destructive, the process would not be active on surfaces covered with snow (most of the plateau), as alternate freezing and thawing would not occur. In spring and autumn, melting and freezing of ice and water does take place over practically the whole region; but these periods are so short, owing to the long winter, that weathering by frost action is not extensive. This is evident at Lake Albina and the Blue Lake where glaciated surfaces of granite, covered with snow throughout winter, have not suffered greatly from frost action since they were smoothed and grooved by Pleistocene glaciers. Rocks subjected to abnormal weathering by frost action are those standing above the general surface of snow. Evidence of this is seen at high, rocky points such as Mts. Etheridge, Townsend and Gungartan, where granite has been shattered into irregular blocks and fragments.

Notes on the biological significance of results, recorded in this paper, were kindly supplied by the following writers:

S. J. Copland, B.Sc.—The observations are of particular interest from the standpoint of low temperature tolerance and conditions of hibernation in reptiles. At least six species of lizards and two of snakes are non-migratory and undoubtedly live the year

round on the high plateau country above 5,000 feet. All the reptiles are small enough (except *Denisonia superba*, and even this snake is much larger at lower altitudes) to avail themselves of the advantageous surface-mass ratio in adsorbing heat. Less work appears to have been done on the behaviour of reptiles at low temperatures with associated problems of hibernation and survival than at critical thermal levels.

The experiment made at an elevation of 6,200 feet, in a typical swampy area on the high plateau country, shows that the minimum winter temperature, a foot below the surface, is slightly more than 2°F. above freezing point, so that the hibernating reptiles at this depth have at no time to undergo the risk of formation of ice crystals in the body and almost certain death. This freezing would not occur even at 32°F. because of the essential presence in the body fluids of substances which lower the freezing point. Mt. Kosciusko reptiles almost certainly hibernate between depths of 9 inches and 3 feet where, the results show, they would have a margin of from 2° to 4·5°F. above freezing point. Although the minimum temperatures of 34° and 36·5°F. recorded at these depths must occur for only part of the winter, it seems certain that they are approached over most of the season, the temperature of 32°F. being rapidly adopted at the ground surface. A margin above freezing point is therefore essential because, while reptiles can successfully endure temperatures below this point for certain periods, exposure for months to freezing conditions could only be expected to cause death from chilling, with formation of ice crystals in the body, increased viscosity of body fluids, checked metabolism, and other disadvantageous physical and chemical changes.

F. V. Mercer, B.Sc.—The Kosciusko winter environment is difficult as the ground is covered with snow, air temperatures frequently fall below zero, and desiccating winds are a common feature of the habitat. Vegetative plant life, which can not withstand such conditions, passes the winter in a dormant phase. An examination of the swamp plants indicates that the majority are hemicryptophytes or geophytes with regenerating buds beneath the soil surface. Annuals are not common, and the deciduous habit is absent.

It is significant that the minimum soil temperature in the swampy area investigated does not fall below 32°F. The dominant type of habit is associated with this. The blanketing effect of the snow enables many plants to survive the winter. With the onset of warmer conditions a rich vegetation springs up from basal buds buried at, or near, the soil surface.

K. E. W. Salter, B.Sc.—Animal ecology demands a knowledge of the various controlling factors prevailing in the environment. The bionomics of insects can be largely correlated with temperature. An ecological study of the insect fauna of the Kosciusko region requires a knowledge of maximum and minimum temperatures, over the yearly cycle, in peats and soils. Many of the insects have subterranean larval stages, and it is most interesting to have so clearly demonstrated the fact that temperatures, at a depth of 3 feet in the peat bed investigated, do not fall below 37°F. during the winter.

Acknowledgements.

The author wishes to acknowledge the assistance of Dr. W. R. Browne in the interpretation and preparation of results for publication, and to express his gratitude to Messrs. S. J. Copland, F. V. Mercer and K. E. W. Salter for their interest in the work and contributions to discussion.

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